THE

ONTARIO WATER RESOURCES

COMMISSION

POLLUTION STATUS AND WATER USES

of

RAT PORTAGE BAY AND WINNIPEG RIVER

1967

A STUDY OF THE POLLUTION
STATUS AND WATER USES OF RAT
PORTAGE BAY AND THE WINNIPEG RIVER

1967

by

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SUMMARY

Few bodies of water in Ontario have achieved the degree of varied use prevalent in Rat Portage Bay. Major uses include controlled discharge for generation of hydro-electric power, transportation of pulplogs, seaplane navigation, swimming, water-skiing, fishing and pleasure boating. In addition, the bay serves as a source of municipal water supply and at the time of the survey provided for disposal of untreated domestic wastes from the Town of Kenora. At the present time, a collector sewer system has been completed and an activated sludge sewage treatment plant is now under design. These improvements will eliminate a major source of pollution entering Rat Portage Bay. Additional sources of domestic wastes include discharges from cottage sites and watercraft.

Findings of this survey demonstrated serious contamination of the water of Rat Portage Bay in the vicinity of Kenora by domestic sewage and the possibility of intermittent discharges of the same wastes to the bay at Norman.

The Winnipeg River below Kenora supports fewer water uses than Rat Portage Bay. Major uses are sport and commercial fishing and the translocation and assimilation of domestic and industrial wastes. Some contamination by domestic wastes was evident in Darlington Bay below Keewatin and the river below Kenora was grossly polluted by sanitary and industrial wastes, of which pulp fibre was the principal pollutant. Of primary concern is the limiting effect of these wastes on the capacity of the river to produce desirable fish species for sport, commercial and subsistence exploitation. The value of the river has been impaired for swimming,

water-skiing and related water contact sports, for domestic and industrial water supply and for pleasure boating and aesthetic enjoyment.

RECOMMENDATIONS

1. Treatment facilities for the removal of suspended solids from the effluents of the Ontario-Minnesota Pulp and Paper Company Limited should be designed, constructed and placed in operation with minimal delay.

2. Construction of the proposed sewage treatment facilities to handle sanitary wastes from the Town of Kenora should proceed without delay. (Discharge of the final effluent from the proposed pollution control plant to the Winnipeg River will avoid problems associated with the input of nutrient substances to Rat Portage Bay.)

3. The adequacy of domestic waste handling facilities should be reviewed and additional surface water sampling should be undertaken at Norman to ensure that inadequately treated sanitary wastes are not being discharged to Rat Portage Bay.

4. Steps should be taken to eliminate the source of bacteriological contamination detected in Darlington Bay below Keewatin.

5. A general survey should be undertaken to determine the adequacy of waste handling and treatment facilities at cottage sites along the shoreline of Rat Portage Bay and the Winnipeg River.

6. Shoreline facilities to receive wastes from boats equipped with sewage holding tanks should be provided to discourage the discharge of boating wastes to Rat Portage Bay.

7. With implementation of treatment facilities to effect a reasonable reduction of the present pollution burden in the waters of Rat Portage Bay and the Winnipeg River, these waters can be rehabilitated to accommodate a variety of water uses. Coinciding with the restoration of satisfactory water quality, integrated planning by the various government agencies responsible for resources management and utilization is necessary to realize the full potential of the Winnipeg River as a multiple-use resource.

A STUDY OF THE POLLUTION STATUS AND WATER USES OF RAT PORTAGE BAY AND THE WINNIPEG RIVER - 1967

INTRODUCTION

This report presents the findings of physical, chemical and biological investigations carried out on Rat Portage Bay and the Winnipeg River, downstream to "the Dalles" during July and August, 1967. The survey was designed to define the nature, magnitude and extent to which these bodies of water have been altered by sanitary and industrial wastes inputs and to relate these findings to possible effects on other water uses of the study area.

GENERAL DESCRIPTION OF THE STUDY AREA

The Lake of the Woods - Winnipeg River drainage area lies in a basin bounded south and west by alluvial plains and north and east by the Precambrian Shield. The study area of Rat Portage Bay and the Winnipeg River lies within the Precambrian formation. Lake of the Woods is drained via three outlets from Rat Portage Bay to the Winnipeg River. East and west these discharges originate at Kenora and Keewatin and a central branch flows over Island Falls. The average daily flow during the period of this investigation (July - August, 1967) was 14,670 cfs; maximum and minimum flows were 20,362 and 10,562 cfs.

The eastern, central and western outlets contributed approximately 32, 65 and 3 percent of the total daily flow, respectively. These outlets unite some distance below their respective dams and falls, in an expanded part of the river. From that location, the river flows northward in somewhat disordered fashion. A number of large islands separate the greatly expanded river into several channels which in turn are themselves broken by numerous small rocky islands. These irregularities divide the river into a chain of large deep areas connected by narrow swiftly flowing stretches.

WATER USES OF THE STUDY AREA

Domestic water supply

The Town of Kenora is provided with a municipally-owned and operated water supply system. Water secured from Rat Portage Bay at a rate of two million gallons per day is distributed following chlorination to eight thousand of the eleven thousand inhabitants of the town. Unserviced sections of the town receive water by tank truck or from wells. The community of Norman pumps water for domestic consumption from Rat Portage Bay during the summer months. During the winter, tank trucks are utilized.

The Town of Keewatin pumps water for domestic use from Portage Bay, an inlet of Rat Portage Bay. Tank trucks are utilized throughout the year for distribution to the town inhabitants.

A substantial number of private cottages, tourist resorts and permanent dwellings are situated on islands and along the shoreline of Rat Portage Bay and the Winnipeg River. Groundwater is unavailable as a source of water for domestic consumption owing to the granite bedrock on which these dwellings are built. As a result, surface water is utilized from the bay and river.

Industrial water supply

The Ontario-Minnesota Pulp and Paper Company Limited uses approximately 23 million gallons of water per day in processing wood pulp. This company obtains its supply from the eastern outlet of Rat Portage Bay.

Recreational uses

Lake of the Woods (Rat Portage Bay) is a highly developed recreational resource maintaining a well-established tourist industry. Private cottages, tourist camps and permanent dwellings occupy much of the available shoreline. Competing for available space on the bay are boats hauling log booms; commercial, private and government aircraft; swimmers; boaters; water-skiers;and fishermen.

While Lake of the Woods is well established as a multiple use water resource, the recreational aspects of water use are developed to a lesser extent on the Winnipeg River. Between Kenora and "the Dalles", there are only four tourist resorts and approximately fifty private cottages. Much of the shoreline is undeveloped. Very little use is made of the river for swimming, water-skiing or pleasure boating. The major recreational activity on the river is sport fishing.

Sport and commercial fishing

Angling pressure on Rat Portage Bay is slight in comparison with pressures exerted on adjacent bays and the open portion of the lake.

Commercial, sport and subsistence fishing on the Winnipeg River represent a major use of that body of water. Daily boat and angler counts were maintained throughout the study period of this investigation. From these observations, it would appear that during the summer months, an average of ten to twelve boats and 30 fishermen per day are engaged in angling on the river between Kenora and "the Dalles". Down-

stream from Transect WR30 (see Figure 1) the river is fished commercially by seven band members of the Dalles Indian Reserve and a fisherman from Kenora. Walleye, sauger, northern pike, yellow perch and sturgeon are sought. In addition to sport and commercial fishing, members of the Dalles Indian Reserve exploit fish as a food source and several band members secure their livelihood by guiding anglers.

Hydro-electric power

Four hydro-electric generating stations are located on the Ontario portion of the Winnipeg River. The Keewatin Power Company and Lake of the Woods Milling Company own and operate stations at the Norman and Keewatin outlets from Lake of the Woods. Stations at Whitedog Falls and Caribou Falls on the Winnipeg River are operated by the Hydro-Electric Power Commission of Ontario.

Waste disposal

At the time of the survey, domestic wastes from Kenora, (population 11,000) were collected in sanitary sewers for discharge without treatment to several locations in Rat Portage Bay, Laurenson's Creek and the Winnipeg River.

A sewer extension programme has now been completed at Kenora which will redirect all domestic wastes from the town to the Winnipeg River below the Ontario-Minnesota Pulp and Paper Company Limited, thereby minimizing the domestic waste problem in Rat Portage Bay. As well, the municipality has under design a 2.0 mgd activated sludge water pollution control plant which will provide treatment of wastes prior to discharge.

The Town of Keewatin (population 2,000) is serviced by a municipal system of night-soil collection for disposal of the bulk of its domestic wastes. In some cases, septic tanks are utilized satisfactorily. A partial sewer system

is provided for collection and conveying of storm and surface water. Some sanitary wastes find access to Portage Bay via these sewers.

Additional sources of sanitary wastes include seepage from sanitary disposal facilities servicing cottages and wastes discharged from watercraft. These sources may have a significant influence on water quality.

Process wastes from the Ontario-Minnesota Pulp and Paper Company Limited constitute the bulk of industrial wastes being discharged to the watercourse. This plant produces 700 tons per day of newsprint using approximately 75% groundwood and 25% sulphite pulp. Mill wastes amounting to approximately 20 million gallons per day are discharged to the Winnipeg River via two sewer outfalls. The main sewer terminates in the river about 1,500 feet below the woodroom and handles wastes from the machine sewers, sulphite sewer and sanitary wastes from the mill. During the study period, sanitary wastes from a portion of the Town of Kenora were also discharging through the mill main sewer. The woodroom sewer discharges into Rideout Bay, just west of the woodroom.

METHODS

Field sampling was carried out in July and August, 1967. A total of 39 transects on the Winnipeg River and 10 transects on Rat Portage Bay were selected for examination of physical, chemical and biological parameters. These locations are illustrated in Figure 1. Sampling sites were selected to provide an indication of the movement of polluting elements throughout all reaches of the river between Rat Portage Bay and"the Dalles" rapids.

Microbiological parameters

Eleven locations were selected and sampled on six consecutive Mondays during the study period. Samples were

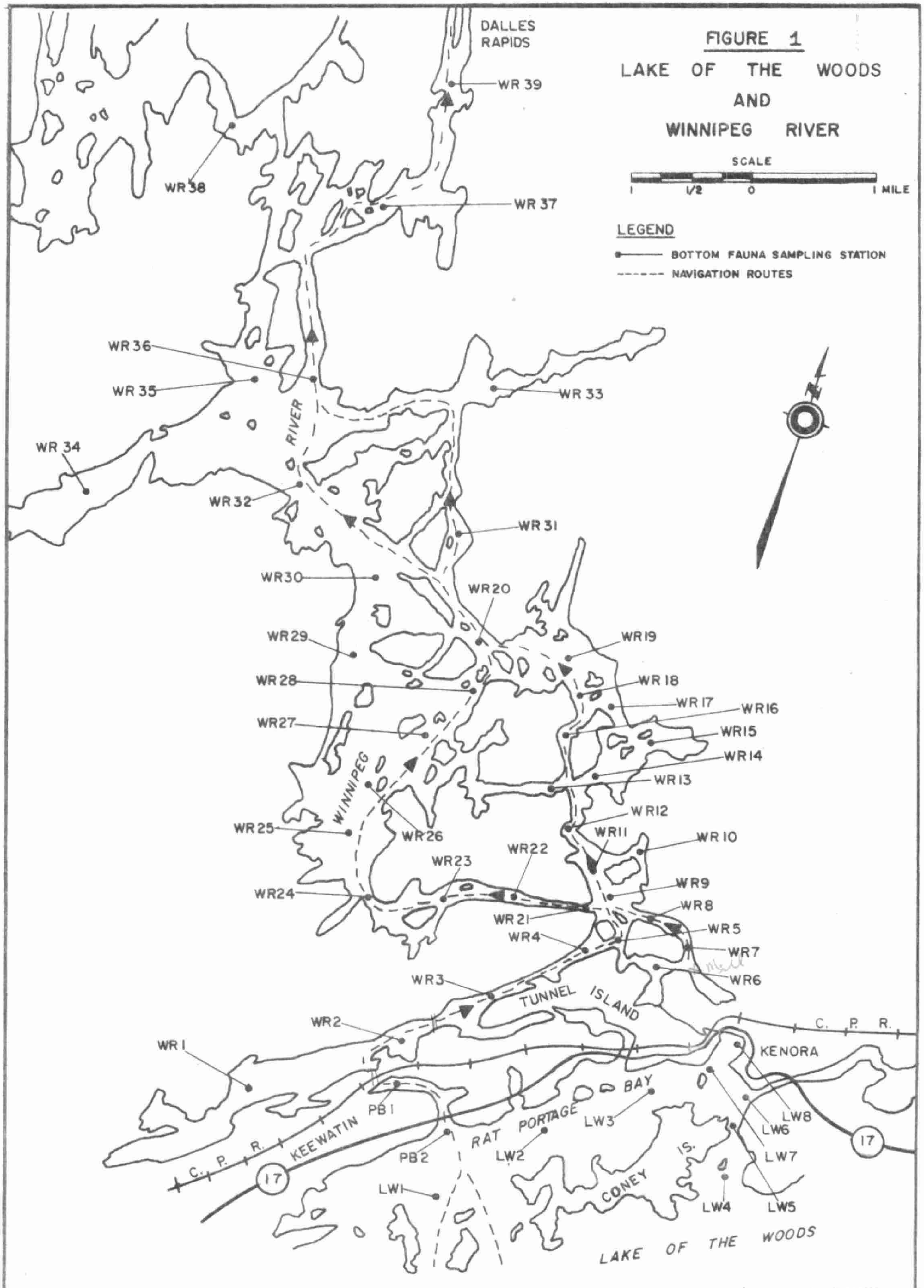
FIGURE 1
LAKE OF THE WOODS
AND
WINNIPEG RIVER
SCALE
1 1/2 0 1 MILE
LEGEND
BOTTOM FAUNA SAMPLING STATION
NAVIGATION ROUTES
DALLES RAPIDS
WR 39
WR 38
WR 37
WR 36
WR 35
WR 34
WR 33
WR 32
WR 31
WR 30
WR 29
WR 28
WR 27
WR 26
WR 25
WR 24
WR 23
WR 22
WR 21
WR 20
WR 19
WR 18
WR 17
WR 16
WR 15
WR 14
WR 13
WR 12
WR 11
WR 10
WR 9
WR 8
WR 7
WR 6
WR 5
WR 4
WR 3
WR 2
WR 1
PB 1
PB 2
LW1
LW2
LW3
LW4
LW5
LW6
LW7
LW8
WINNIPEG RIVER
TUNNEL ISLAND
KENORA
C. P. R.
KEEWATIN
RAT PORTAGE BAY
CONEY IS.
17
LAKE OF THE WOODS
A. LOMBARDI

submitted on the date of collection to the Regional Laboratory of the Ontario Department of Health at Kenora for determination of the most probable number of coliform bacteria.

Threshold odour

Surface water samples at eight sampling transects were secured for threshold odour determinations. Samples were collected on August 14 and shipped air express from Winnipeg to the Biology Branch laboratory. Analyses were carried out as outlined in Standard Methods.

Suspended wood fibre and net plankton

At each of the 39 river transects, 250 gallons of surface water were filtered through a #40 plankton net (mesh opening 153 microns). The residue was preserved with formalin and submitted to the Chemistry II Branch of the Commission. Each sample was filtered through a glass filter paper and washed under vacuum. The paper and solids were dried at 103°C., re-weighed, and the weight of suspended solids calculated. At the same sampling locations, vertical hauls through a 20-foot depth were made with the same #40 plankton net. These samples were examined microscopically to provide a percentage breakdown of suspended solids into plant life, animal life and wood fibre.

Bottom deposits

A Ponar dredge was employed to secure samples of the river sediment. Each dredging received gross examination in the field and the components were classified in order of relative abundance. Core samples from selected stations were retained and examined under microscope.

Phytoplankton

Eight locations were selected and sampled on six consecutive Mondays during the survey. A single water sample was secured at each station from a depth of six to eight feet below surface. Samples were preserved with mercuric chloride and

returned to the Biology Branch laboratory for identification and enumeration.

Bottom fauna

Five replicate Ponar-dredge samples of the sediment were secured from each of the sampling transects. Facing downstream, the samples were secured at five equally-spaced locations from left to right shores of the transect. Sediments obtained were sifted through a box-screen (24-mesh-per-inch) and the invertebrates retained by the screen were sorted into vials of 95% alcohol and returned to the laboratory for microscopic identification and enumeration.

Fish

Standing crops of fish were examined at four locations on the Winnipeg River,using test nets provided by the Ontario Department of Lands and Forests. The gang of gillnets contained 50-foot sections of each mesh size 1½", 2", 2½", 3", 3½", 4", 4½" and 5". Fish captured were enumerated, measured, sexed and examined for stomach content. Scale samples and a copy of the catch records were turned over to the Fish and Wildlife Branch, Department of Lands and Forests, District of Kenora. Age determinations were made by personnel of that Department.

Water chemistry

A single 40-ounce water sample was obtained from each of the sample locations illustrated in Figure 1. All water samples were obtained on August 14th at depths of six to eight feet. The samples were shipped air express from Winnipeg to the Chemistry I Branch of the Commission for determinations of BOD, solids (dissolved and suspended), total Kjeldahl nitrogen and lignins.

PRINCIPLES OF BIOLOGICAL ASSESSMENT OF WATER QUALITY

Microbiological

Classification of the sanitary quality of surface water is based chiefly upon the densities of coliform organisms. These organisms are found in the intestinal tract of man and therefore serve as an indicator of the possible presence of pathogenic organisms. The objective for surface water quality established by the Commission states that surface water should not have densities greater than 2,400 coliform organisms per 100 ml. Multiple use of waters containing greater than the above stated density of coliform organisms should be qualified or restricted.

Macrobiological

Aquatic communities are affected by pollution and the degree of alteration of the normal community structure reflects the extent to which the quality of the water is changed. Normal aquatic communities typical of unpolluted water maintain a flow of energy through reducer, producer and consumer organisms which terminates in production of fish life - the ultimate consumer. In the presence of toxic pollution, the normal transfer of energy is destroyed and only a few of the most tolerant reducer organisms persist. Similarly, organic pollution results in a disruption of energy flow, and the role of the aquatic community shifts from production of fish life to reduction of organic matter. Generally, nutrients released from the assimilation of these wastes provide sufficient fertilization to promote increased biotic production; however, consumer organisms are eliminated owing to their intolerance to by-products of reduction. Conversely, reducer organisms which are tolerant of these water quality changes respond positively to the abundance of food by greatly increasing their

MERCURY

LOCATION: Miscellaneous.

DATE 1976	TYPE OF SAMPLE	LAB. No.	SENDER'S No.	ANALYTICAL RESULTS (PPM.)		MERCURY CONCENTRATION (PPM.)	REMARKS DETAILED LOCATION, ETC.	
June 16	Sediment	M27-28	1	·091	·044	·07	Bruce Lake	Sample 1(E)
	"	-29	3	·079	·050	·06	Pakwash Lake	Chukuni Bay
	"	-30	2	·084	·085	·08	"	Line A
	"	-31	WR 2	·079	·075	·08	Winnipeg R	STN # 2
	"	-32	WR 5	·025	·025	·03	"	" 5
	"	-33	WR 6	·05	·03	·04	"	" 6
	"	-34	WR 7	·134	·039	·08	"	" 7
	"	-35	WR 9	·147		·15	"	" 9
	"	-36	WR 12	·075	·059	·07	"	" 12
	"	-37	WR 16	·124	·106	·12	"	" 16.
	"	-38	WR 18	·416		·42	"	" 18.
	"	-39	WR 19	2.16	1.70	1.9	"	" 19.
	"	-40	WR 20	1.70	1.67	1.7	"	" 19
	"	-41	WR 25	0.86	0.58	·72	"	" 19.
	"	-42	WR 29	1.07	0.97	1.0	"	" 19
1976 29 JUL	"	-43	WR 30	1.47	1.44	1.5	"	" 19
July 15/76	"	131-27				0.30	Balmer Lake - adjacent to Campbell tailings	
	"	131-28				0.53	" " - Dickenson's tailings effluent	
	"	131-29				40.0	Balmer Creek - up from Chukuni River	
	"	131-30				0.94	Influent to SNIB Lake	

population densities. Therefore, a comparison of the relative abundance of reducer and consumer organisms above and below a source of pollution provides a reliable indication of water quality impairment.

These principles provide the basis for water quality assessment in subsequent sections of this report.

FINDINGS

RAT PORTAGE BAY

Sanitary quality

Densities of coliform organisms detected at six locations on Rat Portage Bay on five sampling dates during July and August, 1967 are provided in Table 1.

At three sampling sites densities of coliform organisms were greatly in excess of the Commission's objective. In the vicinity of Kenora densities exceeding 240,000 were repeatedly detected and on the basis of these counts, the entire inlet surrounded by Kenora contained water unfit for domestic and recreational use. In the vicinity of Norman, coliform counts were generally low; however, a count of 2,400 organisms was detected on August 7th indicating the possibility of intermittent discharges of untreated domestic sewage to the surface water at that location. During the study period, the sanitary quality of Portage Bay (Keewatin Harbour) appeared to be satisfactory.

Biological and chemical quality

The variety and abundance of major bottom fauna groups secured at ten sampling locations on Rat Portage Bay are listed in Table 2.

Generally, these data revealed some areas of localized organic pollution but further indicated that the aquatic life of the bay was not grossly altered by domestic waste discharges.

Table 1. Coliform densities at six locations on Rat Portage Bay on five dates during July and August, 1967.

Sampling Location	Date	M.P.N. Total Coliform Organisms per 100 ml.
Between Coney Island and East Shore of Mainland	July 17	2,300
	July 24	230
	August 1	93
	August 7	23
	August 14	240
Mouth of Laurensons Creek	July 17	2,300
	July 24	240,000 +
	August 1	24,000
	August 7	2,400
	August 14	240,000 +
Opposite Kenora Rowing Club	July 17	240,000 +
	July 24	240,000 +
	August 1	240,000 +
	August 7	240,000 +
	August 14	240,000 +
Opposite Kenora General Hospital	July 17	230
	July 24	24,000
	August 1	2,300
	August 7	2,300
	August 14	24,000
Between Island and Community of Norman	July 17	240
	July 24	23
	August 1	0
	August 7	2,400
	August 14	36
Keewatin Harbour Opposite Marr's Marina	July 17	23
	July 24	43
	August 1	23
	August 7	23
	August 14	950

Table 2. Bottom fauna collected at 10 locations on Rat Portage Bay in July, 1967.

					Stations					
Species	LW1	LW2	LW3	LW4	LW5	LW6	LW7	LW8	PB1	PB2
Mayflies	31	60	30	32	54	11	21	7	61	42
Caddisflies					2			1		
Alderflies	3	1	1	2	1	1	12	2	7	5
Midge	40	23	8	29	28	49	76	12	41	65
Crayfish										
Isopods										
Amphipods	16	40	1		1	6				6
Clams		5	1	1	621	7	2	10		
Snails					2	1		1		
Leeches					1	3		1		
Sludgeworms		2	2	2	4	5	2	92		
Miscellaneous	5	3	3	8	12	1	6	1	2	1
Total Organisms	95	134	46	74	725	84	119	127	111	119
Total Taxa	8	12	9	6	19	14	6	12	5	6

Each of the sampling locations contained mayflies, Hexagenia sp. and alderflies, Sialis sp., forms which are sensitive to water quality changes resulting from reduction of organic matter. Forms of moderate tolerance to organic pollution were well-represented by fresh water shrimps, clams, snails and leeches. Pollution-tolerant forms including midge larvae and sludgeworms were also common. While the quality of the bottom fauna remained homogenous throughout the bay, alterations in abundance of some of these forms provided indication of localized water quality impairment in the vicinity of Kenora. These changes included a reduction in the density of pollution-intolerant mayflies, Hexagenia, and a corresponding increase in the density of pollution-tolerant sludgeworms. Areas of organic enrichment were indicated at the mouth of Laurenson's Creek (LW6) and opposite the Kenora Rowing Club (LW8). Coliform densities detected at these same locations were in agreement with and substantiated these findings. Additional indications of organic enrichment were provided by chemical analyses of the surface water. These values appear in Table 3. The maximum concentration of nitrogenous elements occurred at the mouth of Laurenson's Creek, and the total phosphorus levels appeared to be elevated in the eastern portion of the bay.

On five occasions during the study period water samples secured from the western, central and eastern reaches of Rat Portage Bay were examined to determine the relative abundance of tiny water-borne plants known as phytoplankton. These organisms increase in density in response to fertilization; as such, relative abundance of these forms provides a general index of enrichment. Qualitatively, forms present at each of the sampling sites were those characteristic of eutrophic (enriched) waters. Quantitatively, densities increased from an average of 642 areal standard units in the western reaches to 912 in the vicinity of Kenora. These findings provide further evidence of enrichment by domestic wastes from Kenora.

Table 3. Chemical characteristics of surface water in Rat Portage Bay on August 14th, 1967. All determinations expressed in parts per million.

Station	BOD	Suspended Solids	Dissolved Solids	Total Phosphorus	Free Ammonia	Total Kjeldahl Nitrogen
PB2	0.7	2	90	0.01	0.13	0.58
LW1	0.8	3	79	0.02	0.16	0.71
LW2	1.1	3	61	0.01	0.16	0.58
LW3	0.9	6	72	0.03	0.13	0.58
LW5	1.0	7	64	0.05	0.16	0.58
LW6	2.0	4	74	0.03	0.43	0.98
LW7	0.7	4	60		0.15	0.78
LW8	0.7	7	63		0.15	0.58

WINNIPEG RIVER

Sanitary quality

Densities of coliform organisms detected at five locations on the Winnipeg River are provided in Table 4.

Coliform counts at four of the five sampling ranges were in excess of the Commission's objective. Access of untreated domestic wastes to the river from Keewatin was indicated by the presence of 24,000 coliform organisms per ml. in Darlington Bay on August 1st. Excessive coliform densities were detected in the river downstream from Kenora, prevailing to a distance of approximately two miles (midstream opposite Andy's Camp).

Threshold odours

Odours occur in water because of the presence of foreign substances. The occurrence of unnatural odours in surface waters is detected by the Threshold Odour Number (T.O.N.) which represents the number of times an odour-bearing water must be diluted to obtain a concentration at which the odour is barely perceptible. Generally speaking, a reasonable T.O.N. for water of a potable quality for drinking would be four or less.

Table 4. Coliform densities at five locations on the Winnipeg River on five dates during July and August, 1967.

Sampling location	Date	M.P.N. Total Coliform Organisms per 100 ml.
Darlington Bay at bridge Hwy. 595	July 17	2,300
	July 24	2,400
	August 1	24,000
	August 7	23
	August 14	2,400
First rapids downstream from Ontario-Minnesota Pulp and Paper Co.Ltd.	July 17	2,300
	July 24	240,000 +
	August 7	24,000
	August 14	2,400
Downstream from second rapids below paper mill	July 17	24,000
	July 24	24,000
	August 1	24,000
	August 7	110,000
	August 14	2,400
Midstream at Sunnyside Cottages	July 17	230
	July 24	240
	August 1	240
	August 7	290
	August 14	23
Midstream at Andy's Camp	July 17	230
	July 24	2,400
	August 1	24,000
	August 7	2,300
	August 14	1,900

The findings of threshold odour determinations on water samples secured from Rat Portage Bay and the Winnipeg River are listed in Table 5 below.

Table 5. Threshold odour levels of the surface water of Rat Portage Bay and the Winnipeg River, August, 1967.

Station	Threshold Odour Number (T.O.N.)
LW4	4 - 8
WR3	4 - 8
WR5	4 - 8
WR9	4
WR12	4 - 8
WR19	4
WR25	4
WR39	4

These data indicate that there was no detectable change in odour of the surface waters of Rat Portage Bay or the Winnipeg River. The levels obtained indicated that the surface water in the study area at the time of sampling was satisfactory for drinking. The odour detected was generally defined as being musty or grassy.

Suspended and deposited wood fibre

Table 6 indicates the weight and percentage composition of suspended solids removed from 250 gallons of surface water at each sampling range.

No fibre was detected at control ranges WR1, WR2 or WR3. At ranges WR4 through WR6, some fibre was found probably as a result of the discharge of woodroom wastes to Rideout Bay. Below the main mill outlet, wood fibre was detected at all sampling ranges including WR39 located approximately 10 miles downstream.

It should be noted that ranges WR6 through WR25 contained wood fibre concentrations equal to or greater than the median of 2.65 percent, whereas all other ranges contained wood fibre concentrations less than the median value. From these data, it would appear that most of the wood fibre discharged to the river is deposited between ranges WR6 and WR25.

Visual observations on the sediments at each of the 39 sampling ranges on the Winnipeg River are recorded in Table 7. Generally, with the exception of range WR24, wood fibre was common to the sediments at ranges WR7 to WR26 inclusive. Fibre was most abundant in the deep expanded reaches and appeared to be scoured from the shallower constricted portions of the river.

Investigations carried out by McKenzie in 1928 provide evidence of a similar distribution of wood fibre. Conditions in 1928 and 1967 are compared, as follows (McKenzie, 1928).

Table 6. Weight and percentage composition of suspended solids removed from 250 gallons of surface water at 38 locations on the Winnipeg River in August, 1967.

Sta.	Weight milligrams	Percent wood fibre	Percent phytoplankton	Percent zooplankton
WR1	871	0.00	91.23	8.76
WR2	933	0.00	97.25	2.75
WR3	387	0.00	96.71	3.38
WR4	1,622	0.11	97.20	2.67
WR5	1,081	0.21	97.57	2.16
WR6	1,147	2.89	95.08	2.01
WR7	387,530	92.18	7.78	0.03
WR8	22,930	16.88	81.85	1.26
WR9	1,712	60.38	37.55	2.06
WR10	314	4.39	94.66	0.94
WR11	3,699	25.04	73.37	1.57
WR12	2,345	34.35	63.14	2.49
WR13	537	15.42	84.08	0.49
WR14	8,451	32.81	60.85	6.33
WR15	570	-	-	-
WR16	3,354	15.75	83.13	1.09
WR17	623	5.17	92.92	1.90
WR18	1,265	4.56	93.19	2.24
WR19	608	5.55	92.46	1.98
WR20	571	2.65	95.48	1.88
WR21	2,077	8.38	89.55	2.05
WR22	841	6.31	91.82	1.85
WR23	1,061	17.24	81.08	1.67
WR24	1,234	6.68	89.16	4.15
WR25	472	25.45	68.08	6.45
WR26	348	1.89	96.01	2.09
WR27	410	1.52	98.36	0.10
WR28	400	0.01	97.57	1.71
WR29	335	0.74	96.07	3.18
WR30	456	0.18	97.62	2.19
WR31	511	0.30	94.37	5.31
WR32	436	2.16	94.84	2.99
WR33	592	0.01	97.14	2.84
WR34	563	0.23	95.73	4.02
WR35	535	0.06	95.92	4.01
WR36	426	0.61	97.21	2.17
WR37	2,531	0.25	97.54	2.20
WR38	1,192	0.09	97.49	2.41
WR39	470	0.41	97.16	2.42

Table 7. Distribution of deposited pulp wastes at 39 locations on the Winnipeg River. Determination was based on a visual examination of the sediments secured in July and August, 1967 with a Ponar dredge.

Station	Left	Left Centre	Centre	Right Centre	Right
WR1	x	x	x	x	x
WR2	Sawdust	Sawdust	Sawdust	Sawdust	Sawdust
WR3	x	x	x	x	x
WR4	x	x	x	x	x
WR5	x	x	x	x	x
WR6	x	x	x	x	x
WR7	x	Bark,chips	Bark	Knots,chips fibre	Fibre
WR8	Bark,fibre	x	Bark,fibre	Fibre	Chips,fibre
WR9	Bark,fibre	Bark,fibre	Fibre	Fibre	Fibre
WR10	Fibre	Fibre	Fibre	Fibre	Fibre
WR11	Fibre	Fibre	Fibre	Fibre	Fibre
WR12	Fibre	x	Fibre	Fibre	Fibre
WR13	Fibre	Fibre	Fibre	Fibre	Fibre
WR14	Fibre	Fibre	Fibre	Fibre	Fibre
WR15	x	Fibre	Fibre	Fibre	x
WR16	Fibre	Fibre	Fibre	x	Fibre
WR17	Fibre	Fibre	x	Fibre	Fibre
WR18	Fibre	Fibre	Fibre	Fibre	Fibre
WR19	Fibre	Fibre	Fibre	Fibre	Fibre
WR20	Fibre	Fibre	Fibre	Fibre	Fibre
WR21	x	Fibre	x	Fibre	Fibre
WR22	Fibre	Fibre	x	Fibre	Fibre
WR23	Fibre	Fibre	Fibre	x	Fibre
WR24	x	x	x	x	x
WR25	Fibre	Fibre	Fibre	Fibre	x
WR26	Fibre	Fibre	Fibre	Fibre	Fibre
WR27	x	x	x	x	x
WR28	x	x	x	x	x
WR29	x	x	x	x	x
WR30	x	x	x	x	x
WR31	x	x	x	x	x
WR32	x	x	x	x	x
WR33	x	x	x	x	x
WR34	x	x	x	x	x
WR35	x	x	x	x	x
WR36	x	x	x	x	x
WR37	x	x	x	x	x
WR38	x	x	x	x	x
WR39	x	x	x	x	x

x - no fibre visible in sediment.

Station		
WR7 (east)	1928	"Water from 2 - 3 metres deep, flowing swiftly over a bottom covered with bark, chips and pulp."
	1967	Bottom containing bark, chips and coarse wood fibre. No natural sediments.
WR9	1928	"Water about 22 metres deep, flowing slowly over a bottom consisting of 98% pulp, 2% sand. A vile odour given off from this pulpy material. A lot of fine pulp in suspension."
	1967	A complete blanket of undecomposed wood fibre. Depth verified by scuba diver to be between 2 and 3 feet of deposited wood fibre.
WR19	1928	"There was no apparent flow in the water here which is from 25 - 28 metres deep. The bottom was composed of thick, slimy mud which seemed to be decayed organic matter. Very little actual pulp."
	1967	Bottom completely blanketed with decaying wood fibre.

Generally, conditions were similar during both surveys but deposited wood fibre appears to have extended downstream to station WR19 by 1967.

Plankton

Plankters constitute the basic link in the food chain of fish. These minute, water-borne plants and animals form a major portion of the suspended matter present in the Winnipeg River except at several locations downstream from the pulp mill (see Table 6.).

Forty-four genera of phytoplankton (plants) and thirty-two genera of zooplankton (animals) were identified from the surface water of the Winnipeg River. Tables I and II of the Appendix indicate the distribution of these forms.

The major phytoplankters were represented by the blue-greens, *Aphanizomenon*, *Anabaena*, *Microcystis*, *Oscillatoria*; diatoms, *Melosira*, *Fragilaria*, *Tabellaria*; and the flagellate *Ceratium*.

Of these forms, Anabaena, Aphanizomenon, Microcystis and the three species of Melosira which were found (i.e. M. granulata, M. ambigua and M. binderana) are forms characteristic of nutrient enriched waters. Densities of phytoplankton averaged 767 areal standard units per ml. at the control range WR2. As a result of enrichment from Kenora, densities at range WR9 increased to an average of 1240 a.s.u. per ml. Further downstream, conditions similar to the control were indicated by a decrease in density to 739 a.s.u. per ml. at range WR27.

Bottom fauna

Five replicate bottom fauna collections were secured from each of the 39 sampling transects (Figure 1) of the Winnipeg River. Table 9 on page 15a lists these findings condensed to total numbers of major groups per transect. Specific identification data are permanently recorded on OWRC file cards 67B264 to 67B457 inclusive.

Changes in the percentage composition of bottom fauna secured from the Winnipeg River are tabulated below.

Table 10. Changes in percent composition of bottom fauna secured from the Winnipeg River during July and August, 1967.

Pollution tolerance	Transects WR1 to WR6	Transects WR8 to WR28	Transects WR29 to WR39
Intolerant	16.5%	0.3%	7.6%
Facultative	20.2%	6.6%	70.9%
Tolerant	63.3%	93.1%	21.5%

At control transects WR1 to WR6 upstream from the major waste inputs, a balanced fauna consisting of 16.5% intolerant, 20.2% facultative and 63.3% pollution-tolerant organisms provided an indication of the community norm for water of good quality in the Winnipeg River. Comparing this control community with bottom fauna below the mill discharge provides evidence of an influence on water quality owing to these wastes. Between

Table 9. Total bottom fauna collected from five replicate Ponar dredge samples at 39 locations on the Winnipeg River in July and August, 1967.

Station	Mayflies	Caddisflies	Alderflies	Midge	Isopods	Amphipods	Clams	Snails	Leeches	Sludgeworms	Miscellaneous	Total Taxa	Total Organisms
WR1	8		8	117			3			14	125	7	275
WR2	19		2	49			4			3	1	6	78
WR3	6	17	1	128		4	46		2	4	4	21	212
WR4	21	7		123		1	13	7	1	5	10	17	188
WR5	9	11		310		19	53	27	1	12		16	442
WR6	18	14		325	4	29	63	74	9	32	11	25	579
WR7	5	57		200	32	80	4	20	4	15	9	24	426
WR8	1			134	1	3	1		1	12	1	8	154
WR9	1			140						4		3	145
WR10	1			47				2		2	1	6	53
WR11				43						3		2	46
WR12	2			142			11	22	2	14	2	12	195
WR13				27			34	6	1	4		8	72
WR14		1		11			11	1	3	340	1	11	368
WR15	1			55			16	2		21		7	95
WR16		2		82		2	32	21	8	22	1	12	170
WR17				14			56	2		42		6	114
WR18				17			13			3139		4	3169
WR19				17			8			2551		3	2576
WR20				62			28	1			1	4	93
WR21	2			1448		18	2		44	20		10	1534
WR22		1		545		5	3	4	2	7		9	567
WR23	2			28		8	11	41	3	10		9	103
WR24		1		156		68	42	10	13	97	7	19	394
WR25				95		53	33		7	9	2	10	199
WR26				55			3			9	1	4	68
WR27	2			33			22			42		5	99
WR28	1			78			1					3	80
WR29	20		1	88			41	2	2	13	1	10	168
WR30				56			58					4	114
WR31	17	1		39			4	1		2	4	10	68
WR32	21		1	72		2	73	2	2	10	5	13	188
WR33	24		4	51			10	2			1	9	92
WR34	39		7	24			3			3	17	8	93
WR35	3			23			43		2	3		7	74
WR36	15			139		6	178	1		2	1	10	342
WR37	9	3		169		10	138	12	6	28	1	17	376
WR38	92		14				93	1			19	8	220
WR39	6	5		88		111	2278	41	27	144	7	20	2707

transects WR8 and WR28, a complete dominance of the bottom fauna by pollution-tolerant forms was evident. These forms represented 93% of the total organisms secured, whereas only 0.3% of the fauna were organisms intolerant to organic pollution and a similarly low 6.6% were forms of moderate pollution tolerance. Further downstream, between transects WR29 and WR39, improved water quality was indicated by the gradual re-establishment of pollution-intolerant organisms and a reversal of dominance from tolerant to facultative forms. From these changes in abundance of major fauna groups, three zones of water quality corresponding to normal (WR1 to WR6), degradation (WR8 to WR28) and recovery (WR29 to WR39) were apparent. Examination of changes in variety and abundance of organisms from transect to transect provides further basis for the above water quality classification. These differences were as indicated below:

Table 11. Changes in the variety and abundance of bottom fauna secured from the Winnipeg River in July and August, 1967.

	WR1 to WR6	WR8 to WR28	WR29 to WR39
Taxa per transect			
Maximum	25	19	20
Minimum	6	2	4
Median	16	7	10
Mean	15.3	7.3	10.5
Organisms per transect			
Maximum	579	3169	2707
Minimum	78	46	68
Median	188	145	168
Mean	295	490	398

As an average, these figures indicate that transects between WR8 and WR28 contained only one-half the variety of organisms found at the control transects. The maximum variety of organisms (25 taxa/transect) occurred at control transect WR6 and a minimum variety of only two taxa was obtained at transect WR11 both of which were forms tolerant of organic pollution. Further, all of the control, and all but two of

the transects between WR29 and WR39 contained greater than five pollution-intolerant mayflies, caddisflies or alderflies, while all of the 21 sampling transects between WR8 and WR28 had fewer than five of these organisms. Additional evidence of community imbalance was indicated by the range in total numbers of organisms per transect. Comparing transects WR1 to WR6 with WR8 to WR28, the ranges between maximum and minimum numbers of organisms per transect were 78 to 579 and 46 to 3,169 respectively. These figures indicate considerable point to point imbalance in the benthic community resulting from pulp and sanitary wastes discharged to the river.

In 1928, four years after the pulp mill commenced operations, McKenzie sampled bottom fauna at 10 of the 39 locations examined during the present survey. Concerning his bottom fauna investigations the following comments were made:

> "As a result of this study of the bottom fauna of the river it has been found that the coarse material, bark, limbs and chips settle out in the deeper and less rapid parts of the stream within one and one-quarter miles. In this region all the bottom organisms are apparently blotted out. The finer material (wood-pulp) becomes concentrated in the bottom water in similar deep, slow moving parts of the river within three and one-half miles of its point of introduction. As a result of the decomposition of this fine material the oxygen content of the bottom water appears to become lowered as far as five miles from the source of pollution, as indicated by a large bottom fauna of chironomids and oligochaets. From this point clean water conditions gradually become re-established."

Bark and limbs were not prevalent in 1967, however, the same zone of fibre deposition and macroinvertebrate depredation was detected during both surveys. On both occasions, the maximum density of pollution-tolerant sludgeworms occurred at range WR19. Comparing densities at that location, sludgeworms were approximately fifteen times more abundant in 1967 probably owing to greater abundance of food in the form of wood fibre.

Fish

Standing crops of fish were estimated at Transects WR11, WR19, WR27 and WR36. It should be understood that the data secured represent instantaneous standing crops, and a much more intensive sampling programme would be required in order to draw valid conclusions concerning the distribution and abundance of fish in the Winnipeg River. However, the data provide basis for some inferences. Six species of fish including walleye, Stizostedion vitreum, sauger, Stizostedion canadense; yellow perch, Perca flavescens; pike, Esox lucius; cisco, Coregonus sp., and suckers Catostomus sp. were secured. Walleye and sauger were represented at each sampling site. Of the ten representatives of these species secured at WR11, only age classes two and three were present, total lengths ranged from 9.6 to 12.8 inches, only one-third of these specimens contained food in their stomachs and all were captured in a concentrated school. In comparison, of the 30 walleye and sauger secured at WR27, age classes two to five were represented, total lengths ranged from 9.0 to 20.0 inches, two-thirds contained food in their stomach and individuals were randomly distributed throughout the net. These facts suggest that the walleye and sauger secured at WR11 below the mill discharge were transients whereas those secured at WR27 were probably part of a stable community. Yellow perch, pike and cisco were either absent or less abundant at the sampling sites most proximal to the wastes input, whereas the converse was true for the pollution-tolerant filter-feeding suckers.

Similar results were obtained by McKenzie in 1928. His sampling demonstrated the presence of fish at all sampling sites, including a set in the vicinity of WR11, about which he made this comment, "But the fact that fish were taken at these stations does not mean that they were securing their living there." The efficiency of gill netting was affected by pulp wastes during both surveys. McKenzie states,"More extensive settings should have been made, but the nets became very much torn with limbs and logs and too badly fouled with pulp, bark

Dissolved oxygen levels were measured at 11 stations on three sampling days during the survey, as illustrated in Table IV of the Appendix. Only slight changes were detected, and the levels present were considered satisfactory for fish life. However, the dissolved oxygen concentrations at the sludge-water interface were not measured. Oxygen concentration at the sludge-water interface is one of the critical factors which dictates the distribution of many important fish food organisms. During a study of the Rainy River, dissolved oxygen concentrations from the sludge-water interface to the surface varied from 0.1 ppm to near saturation below the pulp mills on the Rainy River, (Colby, et al. 1967). This gradient probably exists on the Winnipeg River as well.

INFLUENCE OF EXISTING POLLUTION ON OTHER WATER USES

Maximum utilization of the surface waters of Rat Portage Bay and the Winnipeg River for multiple purposes is important to the economic and social well-being of the region. The regulated discharge of industrial and domestic wastes for transportation, dispersion and assimilation is one of many recognized beneficial uses of most bodies of water. However, unrestrained use of surface waters for wastes disposal may seriously limit the suitability of a body of water for other purposes.

Preceeding sections of this report have established the presence of inadequately-treated domestic and industrial wastes in surface waters of Rat Portage Bay and the Winnipeg River. In this section, the effects of these wastes on beneficial uses will be discussed in light of existing conditions.

Pollution by sanitary wastes

With the provision of a collector sewer system and activated sludge treatment for municipal wastes at Kenora, involving discharge to the Winnipeg River below the Ontario-Minnesota Pulp

and Paper Company Limited, improved water quality will result in Rat Portage Bay both with respect to bacteriological levels and concentrations of fertilizing elements originating from sanitary wastes. For the most part, this should return the surface waters of the study area to a satisfactory sanitary quality. The bacteriological quality of Rat Portage Bay may continue to be affected by the numerous cottages in this area and the increasing number of cruiser-type watercraft which dock at Kenora.

Use of the upper reaches of the Winnipeg River in the vicinity of Keewatin for domestic consumption or water contact sports obviously remains jeopardized by bacteriological inputs from a portion of Keewatin.

Pollution by pulp wastes

Domestic water supply

Besides being free of pathogenic organisms and noxious odours potable water should be free of suspended matter. The presence of suspended wood fibre lowers the quality of Winnipeg River water for domestic use at cottages downstream from the mill.

Industrial water supply

Process water for industrial use must be of a high quality. The presence of suspended wood fibres would be incompatible to almost all industrial processing including the production of newsprint. There is no industry located downstream from the pulp mill at Kenora, nor is there a likelihood that any industry could be attracted to locate in areas affected by the present pulp mill discharge.

Boating and aesthetic enjoyment

The extent to which the aesthetic quality of the Winnipeg River has been altered by pulp wastes is probably best exemplified by the limited extent of shoreline development for cottage, resort and parkette use and the equally limited utilization of

the river for camping and pleasure boating. Among the aesthetically displeasing qualities of the pulp wastes discharged to the Winnipeg River are: (1) discolouration of the surface water; (2) formation of an island of pulp wastes downstream from the mill; (3) floating mats of wood fibre released from the river bottom and; (4) pock-marking of the river surface by escaping gas bubbles associated with organic decomposition on the river bottom.

Water-contact sports

These activities were not prevalent on the Winnipeg River during the study period. The lack of river use for these purposes is obviously related to unsightly conditions created by the presence of suspended wood fibres visible for a considerable distance downstream from the pulp mill discharge.

Propogation of fish and other aquatic life

Generally, in polluted waters, sustenance of viable native fish populations requires maintenance of optimum concentrations of dissolved oxygen, adequate sources of food, absence of toxic substances and absence of silt or organic sludge deposits which destroy suitable spawning sites. The findings of this study provide direct evidence of harmful fibre sludge deposits and elimination of fish food organisms. Also, studies by Colby (1967) linked fibre sludge beds with oxygen deficiency and H_2S concentrations near the sludge-water interface that were lethal to early life history stages of fish and some fish food organisms. It is reasonable to assume that these relationships also exist in the Winnipeg River.

Fish of major sport and commercial value indigenous to the Winnipeg River are sturgeon, walleye and pike. Alterations in the bottom fauna of the river downstream from Kenora disrupt the food chain of each of these species. Mayflies, amphipods, clams and snails are the preferred food

organisms of sturgeon (Dymond, 1926, Vladykov, 1963 and Scott, 1967). Hunt and Carbine (1951), McCarraher (1957) and Franklin and Smith (1963) demonstrated that the food selection of pike follows a sequence of microcrustacea, insect-amphipod, and vertebrates. Studies by Smith (1960) provide evidence of walleye dependence on copepoda, cladocera and insect larvae during their juvenile period.

Wood fibres were detected in suspension at all ranges between Kenora and "the Dalles" rapids. A series of studies from the Minnesota Agricultural Experimental Station have demonstrated that long-term exposure of fish to sublethal levels of suspended wood fibre result in physiological stress and ultimately poor fish production. Some demonstrated effects include decreased growth rate (Kramer, 1965) and swimming endurance, increased energy requirements necessary for routine body maintenance (MacLeod, 1966) as well as significant changes in the blood of fish (Smith, 1965).

Based on the findings of the present survey and supporting research, it is obvious that pulp wastes are interfering with the optimum production of game and commercial fish species in the Winnipeg River.

Exploitation of fish

Commercial, sport and subsistence fishermen, as well as resort operators, tourist outfitters and guides are influenced by the discharge of wood fibres which at least in part determine the availability of desirable fish species. Fishing pressure and success are minimal closer to Kenora in comparison to the lower reaches of the river. In addition to these effects, suspended wood fibres also foul gill-nets which decrease their fishing ability, increase maintenance costs and shorten the life expectancy of the gear.

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APPENDIX

Table I	Zooplankton collected at 38 stations on the Winnipeg River during the summer of 1967.
Table II	Phytoplankton identified at 38 stations on the Winnipeg River during August, 1967.
Table III	Results of chemical analyses of water samples collected from the Winnipeg River in August, 1967. Sample locations are shown in Figure 1.
Table IV	Dissolved oxygen concentrations (near bottom) at 11 stations on the Winnipeg River. Temperature range 17 - 21°C.

Table I. Zooplankton collected at 38 stations on the Winnipeg River during the summer of 1967.

Taxa / Station	ROTIFERA Ascomorphella	Asplanchna	Brachionus	Chromogaster	Colurella	Conochilus	Dicranophorus	Drilophaga	Filinia	Kellicottia	Keratella	Lecane	Lepadella	Monostyla	Notholca	Notommata	Pleosoma	Polyarthra	Synchaeta	Tricocera
WR1		x	x	x		x			x	x	x				x		x	x	x	
WR2		x	x														x	x	x	
WR3				x						x	x	x					x	x	x	
WR4	x		x	x				x	x	x	x						x	x	x	
WR5		x		x						x	x						x	x		
WR6			x							x	x						x	x		
WR7										x	x									
WR8			x							x									x	
WR9									x	x								x	x	
WR10			x	x	x		x		x	x		x	x	x				x	x	x
WR11				x						x	x							x	x	
WR12				x						x	x						x	x	x	
WR13				x						x	x			x			x	x		
WR14										x	x							x		
WR16										x	x							x		
WR17				x						x							x	x	x	
WR18			x	x					x	x	x		x				x	x	x	
WR19				x						x	x							x	x	
WR20			x	x						x	x							x	x	
WR21									x	x	x							x		
WR22				x						x								x		
WR23										x	x						x	x	x	
WR24										x	x						x	x	x	
WR25				x						x	x							x	x	
WR26				x						x	x						x	x	x	
WR27										x	x							x	x	
WR28						x			x	x	x						x	x		
WR29		x		x		x				x	x							x	x	
WR30				x		x			x	x	x						x	x	x	
WR31		x		x						x	x							x	x	
WR32				x						x	x						x	x	x	
WR33		x		x		x			x	x	x						x	x		
WR34		x	x			x				x	x							x		
WR35		x	x	x		x			x	x	x							x	x	
WR36										x	x							x	x	
WR37		x		x					x	x	x			x				x	x	
WR38		x							x	x	x							x	x	
WR39		x	x			x				x	x					x		x	x	

Table I. continued......

Station	CRUSTACEA	CLADOCERA	Alona	Bosmina	Chidorus	Daphnia	Holopedium	Leptodora	CALANOIDA	Diaptomus	Epischura	CYCLOPODA	Cyclops	Mesocyclops	HARPACTICODD	Canthocamptus	Nauplius larvae
WR1				x						x				x			x
WR2						x				x				x			x
WR3						x				x				x			x
WR4					x	x				x			x	x			x
WR5				x		x				x			x	x			x
WR6										x				x			x
WR7																	
WR8			x							x				x			x
WR9						x				x				x			x
WR10										x			x				x
WR11					x		x			x				x			x
WR12					x	x				x				x			x
WR13										x				x			x
WR14						x		x		x	x			x			x
WR16						x				x							x
WR17			x							x			x	x			x
WR18						x				x			x	x			x
WR19								x		x			x				x
WR20			x					x		x				x			x
WR21					x	x				x			x	x			x
WR22										x				x			x
WR23						x				x			x	x			x
WR24						x				x				x			x
WR25						x				x				x			x
WR26										x				x			x
WR27										x			x				x
WR28										x				x			x
WR29														x			x
WR30										x				x			x
WR31										x				x			x
WR32					x					x							x
WR33				x						x			x	x			x
WR34						x				x			x				x
WR35										x						x	x
WR36										x				x			x
WR37										x				x			x
WR38						x				x				x			x
WR39										x				x			x

Table II. Phytoplankton identified at 38 stations on the Winnipeg River during August, 1967.

Taxa / Station	MYXOPHYCEAE *Anacystis*	*Anabaena*	*Aphanizomenon*	*Aphanothece*	*Chroococcus*	*Gomphosphaeria*	*Lyngbya*	*Microcystis*	*Nostoc*	*Oscillatoria*	*Phormidium*	CHLOROPHYCEAE *Actinastrum*	*Chlamydomonas*	*Chlorella*	*Coelastrum*	*Dictyosphaerium*	*Eudorina*	*Kirchneriella*	*Micractinium*	*Mougeotia*
WR1	x	x	x			x				x			x			x	x			
WR2	x	x	x					x		x			x							
WR3	x	x	x			x		x	x	x							x			x
WR4	x	x	x						x	x										
WR5	x	x	x			x		x	x											
WR6		x	x				x	x		x			x							
WR7		x	x			x				x										
WR8		x	x				x			x							x		x	
WR9		x	x			x	x													x
WR10	x	x	x	x	x	x		x	x	x							x	x		
WR11	x	x	x		x	x	x													
WR12		x	x						x	x			x				x			
WR13	x	x	x							x										
WR14	x	x	x							x										
WR16		x	x							x										
WR17		x	x			x		x		x	x							x		
WR18		x	x					x												
WR19		x	x					x		x										
WR20		x	x							x							x			
WR21		x	x					x		x										
WR22		x	x					x		x										
WR23		x	x							x				x						
WR24		x	x					x		x										
WR25		x	x					x		x										
WR26		x	x							x										
WR27	x	x	x					x	x											
WR28		x	x							x			x				x			
WR29		x	x			x		x		x			x							
WR30		x	x					x		x			x							
WR31		x	x					x		x							x			
WR32		x	x			x		x		x					x		x			
WR33	x	x	x					x		x							x			
WR34	x	x	x			x				x							x			
WR35		x	x					x		x		x					x			
WR36	x	x	x							x										
WR37		x	x			x				x										
WR38		x	x			x				x										
WR39		x	x					x												

Table II. continued........

Station \ Taxa	Oocystis	Pandorina	Pediastrum	Schroederia	Staurastrum	Ulothrix	Volvox	CHRYSOPHYCEAE	Dinobryon	Synura	EUGLENOPHYCEAE	Trachelomonas	DINOPHYCEAE	Ceratium	Peridinium	CHRYPOPHYCEAE	Cryptomonas	BACILLARIOPHYCEAE	Asterionella	Diatoma	Fragilaria	Gomphonema	Gyrosigma	Melosira	Navicula	Nitzschia	Rhizosolenia	Synedra	Tabellaria
WR1									x	x				x					x		x			x				x	x
WR2									x					x					x		x			x			x	x	x
WR3					x				x					x					x	x	x	x		x					x
WR4									x					x					x		x			x				x	x
WR5			x						x					x					x		x			x	x			x	x
WR6					x				x					x	x				x		x			x				x	x
WR7														x			x		x		x		x	x				x	x
WR8									x					x					x	x	x			x	x	x		x	x
WR9									x					x					x	x	x			x				x	x
WR10			x				x		x					x					x		x			x				x	x
WR11					x				x					x					x		x			x				x	x
WR12					x				x			x		x					x		x			x				x	x
WR13			x		x				x					x					x		x			x				x	x
WR14					x				x						x				x		x			x		x		x	x
WR16					x									x	x				x		x			x					x
WR17	x			x					x					x					x		x			x				x	x
WR18									x						x				x		x			x				x	
WR19									x										x		x			x				x	x
WR20									x					x					x		x			x				x	x
WR21									x					x					x		x			x		x			x
WR22		x			x									x	x				x		x			x					x
WR23		x												x					x		x			x					x
WR24									x					x					x		x			x				x	x
WR25	x								x					x					x		x			x				x	x
WR26		x							x					x	x				x		x			x					x
WR27					x									x					x		x			x				x	x
WR28						x			x					x					x		x								x
WR29		x			x									x	x				x		x			x				x	x
WR30									x	x				x					x		x			x				x	x
WR31									x	x				x					x		x			x				x	x
WR32					x				x					x					x		x			x				x	x
WR33		x							x	x				x					x		x			x			x		x
WR34					x	x			x					x					x		x			x			x	x	x
WR35						x			x	x				x					x		x			x				x	x
WR36		x			x				x					x					x					x				x	x
WR37					x				x	x				x					x		x			x					x
WR38					x									x					x		x			x					x
WR39					x									x					x		x			x					x

Table III. Results of chemical analyses of water samples collected from the Winnipeg River in August, 1967. Sample locations are shown in Figure 1.

Station	BOD	Solids Susp.	Solids Diss.	Total Kjeldahl Nitrogen	Lignins
WR1	1.7	2	60	0.78	0.5
WR2	0.8	9	97	0.58	0.5
WR3	1.0	6	64	0.58	1.0
WR4	0.8	6	60	0.71	0.5
WR5	0.7	7	59	0.46	0.5
WR6	0.8	7	59	0.52	0.5
WR8	4.4	12	88	0.84	2.0
WR9	2.4	6	74	0.71	1.5
WR10	2.8	3	59	0.71	1.5
WR11	2.3	5	69	0.52	1.5
WR12	3.2	6	64	0.52	1.5
WR13	1.7	6	62	0.71	1.0
WR14	1.9	6	76	0.71	1.0
WR15	1.8	6	66	0.71	1.0
WR16	1.8	5	83	0.71	1.0
WR17	1.8	5	87	0.58	1.5
WR18	1.8	5	67	0.58	1.0
WR19	1.8	6	72	0.52	1.0
WR20	1.9	5	85	0.84	1.0
WR21	2.0	6	46	0.58	1.5
WR22	1.5	4	88	0.52	1.0
WR23	1.6	2	76	0.71	1.0
WR24	0.8	5	73	0.71	1.0
WR25	1.2	6	69	0.58	1.0
WR26	1.0	3	59	0.58	1.0
WR27	1.1	1	63	0.58	1.0
WR28	1.1	3	87	0.71	1.0
WR29	1.1	5	85	1.50	1.0
WR30	1.2	5	61	0.33	1.0
WR31	1.5	1	61	0.58	1.0
WR32	1.1	2	67	0.58	1.0
WR33	0.9	2	59	0.71	1.0
WR34	0.8	3	87	1.20	1.0
WR35	1.1	1	67	0.46	1.0
WR36	1.1	1	77	0.46	1.0
WR37	1.0	2	60	0.52	1.0
WR39	0.7	1	65	0.71	1.0

Table IV. Dissolved oxygen concentrations (near bottom) at eleven stations on the Winnipeg River. Temperature range 17 - 21°C.

Station	Date	Dissolved Oxygen
WR3	July 25, 1967	8.0 ppm
	August 12, 1967	8.0 ppm
	August 16, 1967	9.5 ppm
WR4	July 25, 1967	9.0 ppm
	August 12, 1967	8.0 ppm
	August 16, 1967	8.5 ppm
WR6	August 12, 1967	8.0 ppm
	August 16, 1967	6.5 ppm
WR7	July 25, 1967	4.0 ppm
	August 12, 1967	7.5 ppm
	August 16, 1967	7.5 ppm
WR8	July 25, 1967	7.5 ppm
	August 12, 1967	7.5 ppm
	August 16, 1967	6.5 ppm
WR11	August 12, 1967	7.5 ppm
	August 16, 1967	7.0 ppm
WR12	August 12, 1967	7.5 ppm
	August 16, 1967	7.5 ppm
WR14	August 12, 1967	7.5 ppm
	August 16, 1967	7.5 ppm
WR17	August 12, 1967	6.5 ppm
	August 16, 1967	6.5 ppm
WR20	July 25, 1967	7.5 ppm
	August 12, 1967	8.0 ppm
	August 16, 1967	8.5 ppm
WR23	August 12, 1967	7.5 ppm
	August 16, 1967	6.5 ppm